Claims

1.   A battery capacity calculating method for calculating a residual capacity and/or residual power of a secondary battery, comprising:

5   an equilibrium voltage curve calculating step for calculating an equilibrium voltage curve C_{equ} showing a relation between a discharged capacity and an equilibrium voltage in said secondary battery;

            a voltage current measuring step for measuring a terminal voltage V_{mea} and a current value I of said secondary battery at a time of discharging;

10   a discharged capacity calculating step for calculating a discharged capacity Q_{mea} of said secondary battery based on the terminal voltage V_{mea} and the current value I, both measured at said voltage current measuring step;

            an apparent equilibrium voltage calculating step for calculating an apparent equilibrium voltage V_{ocv} by adding a voltage drop ΔV_{dc} by a direct current resistance

15   R_{dc} to the terminal voltage V_{mea};

            an apparent discharged capacity calculating step for calculating an apparent discharged capacity Q_{ocv} corresponding to the apparent equilibrium voltage V_{ocv} calculated at said equilibrium voltage calculating step based on the equilibrium voltage curve Q_{equ} calculated at said equilibrium voltage curve calculating step;

20   a capacity shift calculating step for calculating a capacity shift ΔQ being a difference between the discharged capacity Q_{mea} and the apparent discharged capacity Q_{ocv}; and

            an estimating step for estimating a discharge curve C_{pre} in a future based on the capacity shift ΔQ calculated at said capacity shift calculating step.

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2.   The battery capacity calculating method according to claim 1, wherein at said estimating step, when a state of said battery is close to the last stage of discharging, a reduction rate dQ of a capacity shift to a discharged capacity is calculated based on the discharged capacity Q_{mea} calculated at said discharged capacity calculating step and

30   the capacity shift ΔQ calculated at said capacity shift calculating step, and the discharge curve C_{pre} in the future is estimated based on the capacity shift ΔQ and the

reduction rate dQ.

3.   The battery capacity calculating method according to claim 2, wherein the capacity shift ΔQ is expressed by a linear function of the discharged capacity Q_{mea}

5   when the state of said battery is close to the last stage of discharging.

4.   The battery capacity calculating method according to claim 1, wherein at said estimating step, when a state of said battery is not in the last stage of discharging, the equilibrium voltage V_{equ} corresponding to the discharged capacity Q_{mea} is calculated

10   based on the equilibrium voltage curve C_{equ}, and the discharge curve C_{pre} in the future is estimated based on the voltage drop ΔV being the difference between the equilibrium voltage V_{equ} and the terminal voltage V_{mea}.

5.   The battery capacity calculating method according to claim 4, wherein at said

15   estimating step, the discharge curve C_{pre} is estimated by subtracting the voltage drop ΔV from the equilibrium voltage curve C_{equ}.

6.   The battery capacity calculating method according to claim 4, wherein at said estimating step, the discharge curve C_{pre} is estimated using a maximum voltage drop

20   ΔV_{max} corresponding to a maximum load by present in place of the voltage drop ΔV.

7.   The battery capacity calculating method according to claim 1, further comprising a residual capacity/residual power calculating step for calculating the residual capacity and/or the residual power of said secondary battery based on the

25   discharge curve C_{pre} estimated at said estimating step.

8.   The battery capacity calculating method according to claim 1, further comprising a step for performing a judgment whether a state of said battery is near the last stage of discharging or not based on the apparent equilibrium voltage V_{ocv} to

30   switch an estimating method of the discharge curve C_{pre} according to a judgment result.

9.   The battery capacity calculating method according to claim 8, wherein at said switching step, the apparent equilibrium voltage V_{ocv} is compared with a predetermined threshold value to perform the judgment whether the state of said battery is near the last stage of discharging or not.

10.   The battery capacity calculating method according to claim 1, wherein at said apparent equilibrium voltage calculating step, the direct current resistance R_{dc} is calculated based on voltage changes according to current changes.

11.   The battery capacity calculating method according to claim 1, wherein at said apparent equilibrium voltage calculating process, the direct current resistance R_{dc} is calculated based on an average voltage and an average current value.

12.   The battery capacity calculating method according to claim 1, wherein at said equilibrium voltage curve calculating step, the equilibrium voltage curve C_{equ} is calculated based on equilibrium voltages at at least two points and a capacity between the equilibrium voltages.

13.   The battery capacity calculating method according to claim 12, wherein at said equilibrium voltage curve calculating step, a shrinkage ratio S expressed by a quotient obtained by dividing a fully charged capacity of the secondary battery by a fully charged capacity of an initial battery which is not deteriorated based on the equilibrium voltages at the at least two points and a capacity between the equilibrium voltages.

14.   The battery capacity calculating method according to claim 1, wherein at said equilibrium voltage curve calculating step, charging is compulsorily stopped and an equilibrium voltage is obtained based on a subsequent voltage change.

15.   The battery capacity calculating method according to claim 1, wherein at said

residual capacity/residual power calculating step, the calculated residual capacity and/or the calculated residual power are transmitted to an electronic apparatus using said secondary battery as its power supply.

5   16.   A battery capacity calculating apparatus for calculating a residual capacity and/or residual power of a secondary battery, comprising:

voltage measuring means for measuring a terminal voltage V_{mea} of said secondary battery at a time of discharging;

current measuring means for measuring a current value I of said secondary
10   battery at the time of discharging; and

operation processing means for calculating the residual capacity and/or the residual power of said secondary battery,

wherein said operation processing means calculates an equilibrium voltage curve C_{equ} showing a relation between a discharged capacity and an equilibrium
15   voltage in said secondary battery, calculates a discharged capacity Q_{mea} of said secondary battery based on the terminal voltage V_{mea} measured with said voltage measuring means and the current value I measured with said current measuring means, calculates an apparent equilibrium voltage V_{ocv} by adding a voltage drop ΔV_{dc} by a direct current resistance R_{dc} to the terminal voltage V_{mea}, calculates an apparent
20   discharged capacity Q_{ocv} corresponding to the apparent equilibrium voltage V_{ocv} based on the equilibrium voltage curve Q_{equ}, calculates a capacity shift ΔQ being a difference between the discharged capacity Q_{mea} and the apparent discharged capacity Q_{ocv}, and estimates a discharge curve C_{pre} in a future based on the capacity shift ΔQ.

25   17.   The battery capacity calculating apparatus according to claim 16, wherein, when a state of said battery is close to the last stage of discharging, said operation processing means calculates a reduction rate dQ of a capacity shift to a discharged capacity based on the discharged capacity Q_{mea} and the capacity shift ΔQ, and estimates the discharge curve C_{pre} in the future based on the capacity shift ΔQ and the
30   reduction rate dQ.

18.   The battery capacity calculating apparatus according to claim 17, wherein the capacity shift ΔQ is expressed by a linear function of the discharged capacity Q_{mea} when the state of said battery is close to the last stage of discharging.

5   19.   The battery capacity calculating apparatus according to claim 16, wherein, when a state of said battery is not in the last stage of discharging, said operation processing means calculates the equilibrium voltage V_{equ} corresponding to the discharged capacity Q_{mea} based on the equilibrium voltage curve C_{equ}, and estimates the discharge curve C_{pre} in the future based on the voltage drop ΔV being the

10   difference between the equilibrium voltage V_{equ} and the terminal voltage V_{mea}.

20.   The battery capacity calculating apparatus according to claim 19, wherein said operation processing means estimates the discharge curve C_{pre} by subtracting the voltage drop ΔV from the equilibrium voltage curve C_{equ}.

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21.   The battery capacity calculating apparatus according to claim 19, wherein said operation processing means estimates the discharge curve C_{pre} using a maximum voltage drop ΔV_{max} corresponding to a maximum load by present in place of the voltage drop ΔV.

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22.   The battery capacity calculating apparatus according to claim 16, wherein said operation processing means calculates a residual capacity and/or the residual power of said secondary battery based on the estimated discharge curve C_{pre}.

25   23.   The battery capacity calculating apparatus according to claim 16, wherein said operation processing means performs a judgment whether a state of said battery is near the last stage of discharging or not based on the apparent equilibrium voltage V_{ocv} to switch an estimating method of the discharge curve C_{pre} according to a judgment result.

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24.   The battery capacity calculating apparatus according to claim 23, wherein

said operation processing means compares the apparent equilibrium voltage V_{ocv} with a predetermined threshold value to perform the judgment whether the state of said battery is near the last stage of discharging or not.

5   25.   The battery capacity calculating apparatus according to claim 16, wherein said operation processing means calculates the direct current resistance R_{dc} based on voltage changes according to current changes.

26.   The battery capacity calculating apparatus according to claim 16, wherein
10   said operation processing means calculates the direct current resistance R_{dc} based on an average voltage and an average current value.

27.   The battery capacity calculating apparatus according to claim 16, wherein said operation processing means calculates the equilibrium voltage curve C_{equ} based
15   on equilibrium voltages at at least two points and a capacity between the equilibrium voltages.

28.   The battery capacity calculating apparatus according to claim 27, wherein said operation processing means calculates a shrinkage ratio S expressed by a quotient
20   obtained by dividing a fully charged capacity of said secondary battery by a fully charged capacity of an initial battery which is not deteriorated based on the equilibrium voltages at the at least two points and a capacity between the equilibrium voltages.

25   29.   The battery capacity calculating apparatus according to claim 16, wherein said operation processing means compulsorily stops charging and obtains an equilibrium voltage based on a subsequent voltage change.

30.   The battery capacity calculating apparatus according to claim 16, further
30   comprising transmitting means for transmitting the residual capacity and/or the residual power calculated by said operation processing means to an electronic

apparatus using said secondary battery as its power supply.

31.   A battery capacity calculating program capable of being executed by a
computer for calculating a residual capacity and/or residual power of a secondary
5   battery, comprising:

equilibrium voltage curve calculating processing for calculating an
equilibrium voltage curve C_{equ} showing a relation between a discharged capacity and
an equilibrium voltage of said secondary battery;

voltage current measuring processing for measuring a terminal voltage V_{mea}
10   and a current value I of said secondary battery at a time of discharging;

discharged capacity calculating processing for calculating a discharged
capacity Q_{mea} of said secondary battery based on the terminal voltage V_{mea} and the
current value I, both measured by said voltage current measuring processing;

apparent equilibrium voltage calculating processing for calculating an
15   apparent equilibrium voltage V_{ocd} by adding a voltage drop ΔV_{dc} by a direct current
resistance R_{dc} to the terminal voltage V_{mea};

apparent discharged capacity calculating processing for calculating an
apparent discharged capacity Q_{ocv} corresponding to the apparent equilibrium voltage
V_{ocv} calculated by said equilibrium voltage calculating processing based on said
20   equilibrium voltage curve C_{equ} calculated by said equilibrium voltage curve
calculating processing;

capacity shift calculating processing for calculating a capacity shift ΔQ being
a difference between the discharged capacity Q_{mea} and the apparent discharged
capacity Q_{ocv}; and
25   estimating processing for estimating a discharge curve C_{pre} in a future based
on the capacity shift ΔQ calculated by said capacity shift calculating processing.